

CLAIM AMENDMENTS

Claim 1 (Previously Presented) An indirectly heated button cathode for an ion source, comprising:

a button member having a front face for emitting thermionic electrons, when in use, to form a plasma and

a rear face opposite to said front face, for exposure to electron heating when in use, said button member including a collar and a slug secured in said collar, the slug providing respective central portions of the front and rear faces of the button member and being formed of a first material having a first thermionic work function, and

the collar providing respective peripheral portions of said front and rear faces around said central portions, and being formed of a second material having a second thermionic work function greater than said first work function.

Claim 2 (Previously Presented) An indirectly heated button cathode as claimed in Claim 1, wherein said central portion is circular and said peripheral portion is annular.

Claim 3 (Cancelled)

Claim 4 (Cancelled)

Claim 5 (Previously Presented) An indirectly heated button cathode as claimed in Claim 1, wherein at least part of said front face for emitting is concave.

Claim 6 (Previously Presented) An indirectly heated button cathode as claimed in Claim 5, wherein said central portion of said front face for emitting is concave.

Claim 7 (Original) An indirectly heated button cathode as claimed in Claim 1, wherein said second material is tungsten.

Claim 8 (Original) An indirectly heated button cathode as claimed in Claim 7, wherein said first material is tantalum.

Claim 9 (Cancelled)

Claim 10 (Previously Presented) An indirectly heated cathode for an ion source as claimed in Claim 26, wherein said front face is circular having a concentric central portion and an annular outer portion, wherein only said central portion is concave.

Claim 11 (Currently Amended) An indirectly heated cathode for an ion source comprising:

a button member having a front face for emitting thermionic electrons, when in use, to form a plasma, said button member having a rear face opposite to said front face for exposure to electron heating in use, the button member includes a collar piece and a slug piece shrink fit secured in said collar piece, said slug piece providing respective central portions of the front and rear faces of the button member and said collar piece providing respective exposed surrounding portions of said front and rear faces, ~~said slug being formed of a first material having a first thermionic work function, and said collar being formed of a second material having a second thermionic work function greater than said first work function~~ wherein peripheral portion of said front face provided by the collar piece is substantially co-planar with at least a circumferential part of the central portion of said front face provided by the slug piece.

Claim 12 (Cancelled)

Claim 13 (Previously Presented) An indirectly heated cathode as claimed in Claim 11, wherein said slug piece is secured in said collar piece so as to provide a temperature difference between said slug piece and said collar piece when said central portion of said rear face of the button member is exposed to electron heating.

Claim 14 (Previously Presented) A method for creating a plasma for use in ion implantation comprising:

providing an arc chamber with an indirectly heated button cathode having a button member with a front face for emitting thermionic electrons into said arc chamber for acceleration therein to form a plasma and a rear face,

forming a slug to provide respective central portions of the front and rear faces of a first material having a first thermionic work function,

forming a collar to provide respective peripheral portions of said faces of a second material having a second thermionic work function greater than said first work function,

securing said slug in said collar so that said peripheral portions of said faces surround said central portions,

accelerating electrons, thermionically emitted by a filament onto a the rear face of said button member, to heat said button member to cause thermionic emission of electrons from at least said central portion of said front face provided by said slug,

and electrically biasing said cathode to accelerate said thermionically emitted electrons from said front face of said button member to ionize gas molecules in said arc chamber to produce a plasma therein.

Claim 15 (Cancelled)

Claim 16 (Cancelled)

Claim 17 (Previously Presented) An ion source comprising:

an arc chamber having first and second opposed walls,
an indirectly heated button cathode located in said first wall, and

an electron reflector located in said second wall,
said button cathode having a disc-shaped button member with a generally circular front face for emitting thermionic electrons, when in use, to form a plasma in said arc chamber, and a rear face opposite to said front face, for exposure to electron heating in use, said button member comprising a collar and a slug secured in said collar, the slug providing respective central portions of the front and rear faces of the button member and being formed of a first material having a first thermionic work function, and the collar providing respective peripheral portions of said front and rear faces around said central portions, and being formed of a second material having a second thermionic work function greater than said first work function,

said electron reflector having a disc-shaped head member providing a generally circular reflecting face formed of said first material directed towards said front face of said button member, and

a magnet to provide a magnetic field in said arc chamber aligned between said front face of said button member and said reflecting face of said head member to confine electrons to a column extending in said arc chamber between said cathode and said electron reflector.

Claim 18 (Original) An ion source as claimed in Claim 17, wherein said first material is tantalum and said second material is tungsten.

Claim 19 (Cancelled)

Claim 20 (Currently Amended) ~~An indirectly heated cathode as claimed in Claim 19,~~ An indirectly heated cathode for an ion source comprising:

a button member having a front face for emitting thermionic electrons, when in use, to form a plasma and a rear face opposite to said front face for exposure to electron heating in use, the button member comprising a collar piece and a slug piece secured in the collar piece, the slug piece provides respective central portions of the front and rear faces of the button member and the collar piece provides respective peripheral portions of the front and rear faces surrounding said central portions, said slug piece being secured in said collar piece so as to reduce thermal

conduction from the slug piece to the collar piece and provide a temperature difference between the slug piece and the collarpiece when the central portion of the rear face of the button member is electron heated in use; and

wherein the peripheral portion of said front face provided by the collar piece is substantially co-planar with at least a circumferential part of the central portion of said front face provided by the slug piece.

Claim 21 (Previously Presented) ~~An indirectly heated cathode as claimed in Claim 19,~~ An indirectly heated cathode for an ion source comprising:

a button member having a front face for emitting thermionic electrons, when in use, to form a plasma and a rear face opposite to said front face for exposure to electron heating in use, the buttonmember comprising a collar piece and a slug piece secured in the collar piece, the slug piece provides respective central portions of the front and rear faces of the button member and the collar piece provides respective peripheral portions of the front and rear faces surrounding said central portions, said slug piece being secured in said collar piece so as to reduce thermal conduction from the slug piece to the collar piece and provide a temperature difference between the slug piece and the collarpiece when the central portion of the rear face of the button member is

electron heated in use; and

wherein the peripheral portion of said front face provided by the collar piece is substantially co-planar with at least a circumferential part of the central portion of said front face provided by the slug piece;

wherein the collar piece has a central bore accommodating the slug piece, the central bore having an inner end having a reduced diameter, the slug piece being shrink fit in said reduced diameter inner end of the bore.

Claim 22 (Currently Amended) ~~An indirectly heated cathode as claimed in Claim 19,~~ An indirectly heated cathode for an ion source comprising:

a button member having a front face for emitting thermionic electrons, when in use, to form a plasma and a rear face opposite to said front face for exposure to electron heating in use, the button member comprising a collar piece and a slug piece secured in the collar piece, the slug piece provides respective central portions of the front and rear faces of the button member and the collar piece provides respective peripheral portions of the front and rear faces surrounding said central portions, said slug piece being secured in said collar piece so as to reduce thermal conduction from the slug piece to the collar piece and provide a temperature difference between the slug piece and the collar piece

when the central portion of the rear face of the button member is electron heated in use; and

wherein the slug piece protrudes rearwardly relative to the collar piece so that the central portion of the rear face of the button member is rearward of the peripheral portion of said rear face.

Claim 23 (Currently Amended) ~~An indirectly heated cathode as claimed in Claim 19,~~ An indirectly heated cathode for an ion source comprising:

a button member having a front face for emitting thermionic electrons, when in use, to form a plasma and a rear face opposite to said front face for exposure to electron heating in use, the button member comprising a collar piece and a slug piece secured in the collar piece, the slug piece provides respective central portions of the front and rear faces of the button member and the collar piece provides respective peripheral portions of the front and rear faces surrounding said central portions, said slug piece being secured in said collar piece so as to reduce thermal conduction from the slug piece to the collar piece and provide a temperature difference between the slug piece and the collar piece when the central portion of the rear face of the button member is electron heated in use; and

wherein the slug piece and the collar piece of the button

member are made of the same material.

Claim 24 (Currently Amended) A method of creating a plasma for use in ion implantation, comprising the steps of:

providing an indirectly heated button cathode having a button member with a front face and a rear face, said button member comprising a collar piece and a central slug piece secured in the collar piece, the slug piece, ~~being formed of a first material having a first thermionic work function,~~ provides respective central portions of said front and rear faces and the collar piece, ~~being formed of a second material having a second thermionic work function greater than said first work function,~~ provides respective peripheral portions thereof, wherein peripheral portion of said front face provided by the collar piece is substantially co-planar with at least a circumferential part of the central portion of said front face provided by the slug piece,

accelerating thermionic electrons preferentially onto said central portion of said rear face to heat the slug piece relative to the collar piece to cause thermionic emission of electrons from said central portion of said front face,

reducing thermal conduction from the slug piece to the collar piece to provide a temperature difference between the slug piece and the collar piece,

and electrically biasing the cathode to accelerate said

thermionically emitted electrons from said front face to ionize gas molecules to produce a plasma.

Claim 25 (Currently Amended) A method of forming a button member for an indirectly heated cathode for an ion source, the button member having a front face for emitting thermionic electrons, when in use, to form a plasma and a rear face opposite said front face for exposure to electron heating in use, the method comprising the steps of:

- a) providing a collar piece and a slug piece for securing in the collar piece so that the slug piece, ~~being formed of a first material having a first thermionic work function,~~ provides respective central portions of said front and rear faces and the collar piece, ~~being formed of a second material having a second thermionic work function greater than said first work function,~~ provides respective peripheral portions of the front and rear faces surrounding said central portions, the collar piece having a central bore to accommodate the slug piece wherein the central bore has an inner end having a reduced diameter, wherein the peripheral portion of said front face provided by the collar piece is substantially co-planar with at least a circumferential part of the central portion of said front face provided by the slug piece, and
- b) cooling the slug piece in liquid nitrogen to shrink fit the slug piece into the reduced diameter inner end of the

bore in the collar piece.

Claim 26 (Currently Amended) An ion source comprising:

an arc chamber having first and second opposed walls,

an indirectly heated button cathode located in said first wall, and

an electron reflector located in said second wall,

said button cathode having a disc-shaped button member with a generally circular rear face, and a front face for emitting thermionic electrons, when in use, to form a plasma in said arc chamber, at least part of said front face for emitting being concave, said button cathode including a collar and a slug, the slug being secured in the collar, ~~said slug being made of a first material having a first thermionic work function, and said collar being formed of a second material having a second thermionic work function greater than said first work function,~~ so that the slug piece provides respective central portions of said front and rear faces and the collar piece provides respective peripheral portions of the front and rear faces surrounding said central portions, wherein peripheral portion of said front face provided by the collar piece is substantially co-planar with at least a circumferential part of the central portion of said front face provided by the slug piece, and

a magnet to provide a magnetic field in said arc chamber

aligned between said front face of said button member and said electron reflector to confine electrons to a column extending in said arc chamber between said cathode and said electron reflector.